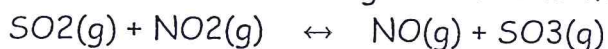


1. At a certain temperature, K_{eq} for the following reaction between sulfur dioxide and nitrogen dioxide is 4.8.



$\text{SO}_2(\text{g})$ and $\text{NO}_2(\text{g})$ have the same initial concentration: 0.36 mol/L.

What amount of $\text{SO}_3(\text{g})$ is present in a 5.0 L container at equilibrium?

mol/L	SO_2	NO_2	\leftrightarrow	NO	SO_3
I	0.36	0.36		0	0
C	-x	-x		+x	+x
E	0.36-x	0.36-x		x	x

$$x = 0.25 \text{ M}$$

$$K_{eq} = \frac{[\text{NO}][\text{SO}_3]}{[\text{SO}_2][\text{NO}_2]}$$

$$4.8 = \frac{(x)(x)}{(0.36-x)^2}$$

$$\sqrt{4.8} = \sqrt{\frac{x^2}{(0.36-x)^2}}$$

$$2.19 = \frac{x}{0.36-x}$$

$$2.19(0.36-x) = x$$

$$0.788 - 2.19x = x$$

$$0.788 = x + 2.19x$$

$$\frac{0.788}{3.19} = \frac{3.19x}{3.19}$$

$$x \approx 0.25 \text{ M}$$

Asking:

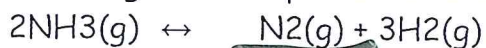
n_{SO_3} in 5.0 L

$$n = C \times V$$

$$= 0.25 \times 5.0$$

$$= 1.3 \text{ mol}$$

2. When 1.0 mol of ammonia gas is injected into a 0.50 L flask, the following reaction proceeds to equilibrium.



At equilibrium 0.30 mol of hydrogen gas is present.

(a) Calculate the equilibrium concentrations of $\text{N}_2(\text{g})$ and $\text{NH}_3(\text{g})$.

(b) What is the value of K_{eq} ?

$$1.0 / 0.5 = 2.0 \text{ M}$$

$$\frac{0.30}{0.50} = 0.60 \text{ M}$$

M	$2\text{NH}_3 \leftrightarrow \text{N}_2 + 3\text{H}_2$		
I	2.0	0	0
C	-2x	+x	+3x
E	2-2x	x	3x

$$K_{eq} = \frac{[\text{N}_2][\text{H}_2]^3}{[\text{NH}_3]^2}$$

$$\begin{aligned} [\text{H}_2]_{eq} &= 0.60 \text{ M} \\ 3x &= 0.60 \\ x &= 0.20 \end{aligned}$$

$$[\text{NH}_3]_{eq} = 2 - 2(0.20) = 1.60$$

$$[\text{N}_2]_{eq} = 0.20$$

$$\begin{aligned} K_{eq} &= \frac{(0.20)(0.60)^3}{(1.60)^2} \\ &= 1.7 \times 10^{-2} \end{aligned}$$

3. Phosphorus trichloride reacts with chlorine to form phosphorus pentachloride. $\text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g}) \leftrightarrow \text{PCl}_5(\text{g})$

0.75 mol of PCl_3 and 0.75 mol of Cl_2 are placed in a 5.0 L reaction vessel at 500 K. What is the equilibrium concentration of the mixture?

The value of K_{eq} at 500 K is 49.

$$\frac{0.75}{5.0} = 0.15$$

mol/L	PCl_3	$+$ Cl_2	\leftrightarrow	PCl_5
I	0.15	0.15		0
C	$-x$	$-x$		$+x$
E	$0.15-x$	$0.15-x$		x

$$K_{\text{eq}} = \frac{[\text{PCl}_5]}{[\text{PCl}_3][\text{Cl}_2]}$$

$$49 = \frac{x}{(0.15-x)^2}$$

$$49(0.0225 - 0.3x + x^2) = x$$

$$1.1025 - 14.7x + 49x^2 - x = 0$$

$$49x^2 - 15.7x + 1.1025 = 0$$

$$x^2 - 0.320x + 0.0225 = 0$$

$$a = 1 \quad b = -0.320 \quad c = 0.0225$$

$$x = \frac{+0.320 \pm \sqrt{(0.32)^2 - 4(0.0225)}}{2}$$

$$x = (0.320 \pm 0.111)/2$$

$$\bar{x}_1 = \frac{0.320 + 0.111}{2}$$

$$= 0.22$$

Rejected.

$$n = \frac{0.320 - 0.111}{2}$$

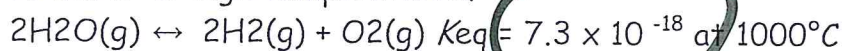
$$0.11$$

✓

$$\begin{cases} [PCl_3]_{eq} = 0.15 - 0.11 \\ \quad \quad \quad = \underline{\underline{0.04}} \text{ M} \\ [PCl_5]_{eq} = 0.11 \text{ M} \end{cases}$$

$$[Cl_2]_{eq} = \underline{\underline{0.04}} \text{ M}$$

4. Hydrogen gas has several advantages and disadvantages as a potential fuel. Hydrogen can be obtained by the thermal decomposition of water at high temperatures.



(a) The initial concentration of water in a reaction vessel is 0.055 mol/L. What is the equilibrium concentration of $\text{H}_2(\text{g})$ at 1000°C ?

(b) Comment on the practicality of the thermal decomposition of water to obtain $\text{H}_2(\text{g})$.

EM

	$2\text{H}_2\text{O}$	\leftrightarrow	2H_2	$+$	O_2
I	0.055		0		0
C	$-2x$		$+2x$		$+x$
E	$0.055 - 2x$		$2x$		x

$\frac{0.055}{7.3 \times 10^{-18}}$ $\gg 1000$ simple math!

{ [Reverse Rxn is the only reaction happening] }

$$\therefore [\text{H}_2\text{O}]_{\text{eq}} \approx [\text{H}_2\text{O}]_{\text{eq}}$$

$$K_{\text{eq}} = \frac{(x)(2x)^2}{(0.055)^2} \quad (x)(4x^2)$$

$$7.3 \times 10^{-18} = 4x^3 / 0.00303$$

$$\frac{(7.3 \times 10^{-18})(0.00303)}{4} = x^3$$

$$\sqrt[3]{5.53 \times 10^{-21}} = x$$

$$1.8 \times 10^{-7} \text{ M} = x$$

$$[\text{H}_2]_{\text{eq}} = 2(1.8 \times 10^{-7})$$

$$= 3.6 \times 10^{-7} \text{ mol/L}$$

b) Not Practical.

5. The following reaction takes place inside a cylinder with a movable piston. $2\text{NO}_2(\text{g}) \leftrightarrow \text{N}_2\text{O}_4(\text{g})$

At room temperature, the equilibrium concentrations inside the cylinder are $[\text{NO}_2] = 0.0206 \text{ mol/L}$ and $[\text{N}_2\text{O}_4] = 0.0724 \text{ mol/L}$.

(a) Calculate the value of K_{eq} .

(b) What will happen if a piston is used to halve the volume of the reaction mixture? Explain why.

(c) Determine the value of *Quotient*, Q , when the volume is halved.

(d) What does the value of Q suggests about the rate of forward and reverse reactions?

$$\text{sa) } K_{\text{eq}} = \frac{[\text{N}_2\text{O}_4]}{[\text{NO}_2]^2}$$

$$= \frac{0.0724}{(0.0206)^2}$$

$$= 171$$

$$C = \frac{n}{V}$$

$$C = \frac{n}{\frac{1}{2}V}$$

$$C = 2 \frac{n}{V}$$

(b) stress is: $P \uparrow$ the system will oppose by lowering pressure by moving forward to make less gas particles.
Le Chatelier

$$\text{c) } Q = \frac{2(0.0724)}{(2 \times 0.0206)^2}$$
$$= 85.3$$

(d) $Q < K_{\text{eq}}$ \therefore the forward reaction is favoured to make more product

#6) At a certain temperature, $K_{eq} = 4.0$ for the following reaction.



A 1.0 L reaction vessel contained 0.045 mol of $\text{F}_2\text{(g)}$ at equilibrium.

What was the initial amount of HF in the reaction vessel?

M	2HF	H ₂	F ₂
I	y	0	0
C	-2x	+x	+x
E	y-2x 0.023 M	x	x

$$K_{eq} = \frac{[\text{F}_2][\text{H}_2]}{[\text{HF}]^2}$$

4.0

$$4.0 = \frac{(0.045)(0.045)}{(y-0.090)^2}$$

$$4.0 = \frac{(0.045)^2}{z^2}$$

$$z^2 = \frac{(0.045)^2}{4.0}$$

$$z = \pm \sqrt{5.06 \times 10^{-4}}$$

$$z = + 2.3 \times 10^{-2} \text{ M}$$

Given

$$[\text{F}_2]_{eq} = \frac{0.045 \text{ mol}}{1.0 \text{ L}}$$

$$= 0.045 \text{ M}$$

$$[\text{H}_2] = 0.045 \text{ M}$$

$$[\text{HF}] = y - 2(0.045)$$

$$= y - 0.090$$

$$y = z + 0.090$$

$$y = 2.3 \times 10^{-2} + 0.09$$

$$= 1.1 \times 10^{-1} \text{ M}$$